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ABSTRACT

Elementary teachers' attitudes towards science and their confidence to teach it have for some time been identified as important in determining both the quality and quantity of science taught to children. Attitudes and confidence are influenced greatly by the teachers' own experiences as learners of science. This paper reports on a longitudinal case study of an elementary teacher during her transition from preservice to inservice teaching. The study identifies experiences that were helpful in overcoming initial lack of confidence in studying science and experiences that were perceived by her to be helpful in preparation for teaching science in the elementary school. Ways in which this beginning teacher perceived and dealt with constraints to science teaching in the elementary school and how she changed and adapted the knowledge and skills developed at university to practical situations are identified. (Contains 26 references.) (Author/NB)

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BEGINNING ELEMENTARY SCIENCE TEACHING: ENTRYWAYS TO DIFFERENT WORLDS

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BEGINNING ELEMENTARY SCIENCE TEACHING: ENTRYWAYS TO DIFFERENT WORLDS

ABSTRACT

Elementary teachers' attitudes towards science and their confidence to teach it, have for some time been identified as important in determining both the quality and quantity of science taught to children (Schoeneberger & Russell, 1986). Attitudes and confidence are influenced greatly by the teachers' own experiences as learners of science (Palmer, 1995; Young & Kellogg, 1993). This paper reports on a longitudinal case study of an elementary teacher, Katie, during her transition from preservice to inservice teaching. The study identifies experiences that were helpful in overcoming initial lack of confidence in studying science and experiences that were perceived by her to be helpful in preparation for teaching science in the elementary school. The paper identifies the ways in which this beginning teacher perceived and dealt with constraints to science teaching in the elementary school and how she changed and adapted the knowledge and skills developed at university in a practical situation.

PERSPECTIVES

Elementary school teachers encounter difficulties with science and science teaching in both the preservice and inservice situations. Large numbers of students entering preservice courses for elementary teachers have very little science background (Fensham, Navaratnam, Jones & West, 1991) and are anxious about studying science themselves and teaching it to children. Many preservice teachers hold naïve realist views of science as a body of discovered knowledge separate from human beings (Abell & Smith, 1994; Gustafson & Rowell, 1995). These beliefs may well account for the fact that, to these teachers, learning science means memorising facts and teaching is presenting content (Abell & Smith, 1994; Young & Kellog, 1993). A number of school-based constraints can prevent field experience from assisting preservice teachers to teach science in a way that will help to increase their confidence (Appleton, 1984; Henderson, 1992). Large numbers of practicing elementary teachers do not teach science and those who do use teacher led discussion, explanation, demonstration or television rather than investigation in their classrooms (Yates & Goodrum, 1990). Teachers claim that they lack the time and knowledge to organise activities and resources for science (Scott, 1989) and that they have had negative experiences with group work and classroom management when teaching science (Goodrum, Cousins & Kinnear, 1992). Many studies show that preservice and inservice elementary teachers have a limited, sketchy or misinformed knowledge of the subject matter they are to teach children (Ginns & Watters, 1995; Jeans & Farnsworth, 1992; Jones, 1991; Kings, 1985; Kruger & Summers, 1989; Summers & Kruger, 1993; Webb, 1992). Problems facing elementary science can be attributed to its low status that is influenced by our culture's sense that it is relatively unimportant for children of this age to study science. Parents consistently concerned about mathematics and reading rarely complain about the minimal attention given to science. It is left to individual teachers to decide how important science will be in their classrooms (Schoenberger & Russell 1986).

Recently there has been a shift in emphasis away from a deficiency model concerned with teachers' shortcomings towards a sensitivity for the teachers' situation and the need to help teachers in their professional growth (Appleton, 1993). It has been suggested that teachers' knowledge and skills be seen in a constructivist light and treated as the base from which developmental changes are made, rather than deficient and in need of remedy (Louden & Wallace, 1990). In writing this paper we have attempted to take a constructivist approach and to interpret the experiences of the teacher participant, Katie in a positive way. We have adopted the term *entryways*, used in the title of this paper, from Roth, Hasbach, Hazelwood, Hoekwater, Ligett, Lindquest, Peasley, and Rosaen, (1993), who described entryways as starting points for science teaching based on the previous experience and interests of the teachers in a professional development project. Katie found a variety of such entryways to science and science teaching, which assisted her to deal with perceived constraints during preservice and inservice teaching.

THE PARTICIPANTS

Katie was a preservice elementary teacher who was enrolled in a three-year Bachelor of Teaching degree at an Australian university. During the second year of this degree preservice teachers studied two units of science education, one in each semester. At the end of each semester they had a four-week field experience in an assigned elementary school. It was usual for them to teach science during this time. In the final year of the degree there were no science subjects but preservice teachers taught science units to children in the field experience blocks at the end of each semester. Katie, who had shown a keen interest in elementary science, was invited to join an ongoing longitudinal study at the end of 1994. In a reflective journal kept during the first science education unit in 1993 Katie outlined her previous experience of science. At school, she studied general science until Year 10 and after this chose chemistry for Years 11 and 12. One of her goals at university was to overcome her negative feelings toward science in the interest of becoming a good science teacher. She had enjoyed science and achieved well in Years 8-10 and was confident that negativity associated with her experiences in Years 11 and 12 could be overcome

The first author, Judith, completed her secondary education in the 1960s. She attended a girls' school and studied Physics, Chemistry and Zoology in her final years at school. Science subjects were considered, by students and staff, to be more difficult than arts subjects and students in the science class enjoyed considerable status. She obtained a Science Degree from the University of Queensland and subsequently a degree in Educational Studies. Her initial teaching position was as a lecturer in Biological Science. After her marriage she taught Biology in high schools in London and then spent some years at home with her children. She returned to full time work as a teacher educator in 1990, after eight years of part-time work in this capacity. She developed an interest in preservice teachers' perceptions of science and the influence these perceptions have on their learning and teaching. She sees her role as motivating and supporting the teaching of elementary science.

METHODS

Qualitative research methods were used in this study in order to make sense of the complex world of teaching and teacher education. The data were collected by Judith who as principal researcher worked with the practitioner in an attempt to better understand practice and enhance its ongoing practicality (Connelly & Clandinin, 1986). She drew on her own experiences, knowledge and theoretical dispositions, to collect data and to present her understanding (Glesne & Peshkin, 1992). The particular interpretative paradigm adopted in this study is constructivist-interpretative with case study as its orchestrating perspective. The study consisted of two phases - a preservice phase and an inservice phase. A variety of data sources were used in the preservice phase of the study, including journals, audio-tapes of interviews and a science background information questionnaire. Katie was required, as part of her course assessment in the first science education unit, to keep a reflective journal to document her progress as a science student during the first semester 1993. Katie was asked to use the journal to discuss topics of importance to her as a learner of science. A semi-structured interview was held at the end of final year of the Bachelor of Teaching in 1994 to document experiences of science teaching that occurred during phase one of the study. In the inservice phase of the study, Katie, kept a written journal during school terms one and two . of 1995. An unstructured interview was held after the first six months of teaching. Classroom observations followed by interviews occurred in the second half of the initial year of employment. A final interview was held in 1996 to explore questions that arose during data analysis. Audio-tape was be used to record classroom interactions and the subsequent interviews. Judith also made field-notes. A process of analytic induction described by Erickson (1986) was used to analyse data from observational notes and interview transcripts. Data sources were read and events, episodes and transactions marked when they represent instances of phenomena of interest. Open coding (Strauss & Corbin, 1990) was used in developing categories into which data could be organised. Analysis was ongoing so that initial interpretations were shared with Katie and altered if necessary. A reflective hermeneutic cycle of writing, thinking and discussion resulted in the presentation of Katie's lived experiences as attempts to find entryways from existing contexts or worlds to new contrasting contexts or worlds.

FINDINGS

Katie can be thought of as a traveler who at various times in her journey toward becoming an experienced teacher, found herself needing to find entries to new worlds contrasting greatly with those she had previously inhabited. As we searched for themes that would allow the unification of the diverse findings of this study, we became aware that it was not possible to meaningfully organise the different experiences of learning science and learning to teach science in a simple way. No themes could be found to reach across the years of teacher education and beginning teaching. However, during this time Katie and Judith frequently found themselves viewing their work from the perspectives of those from another context, a different world. This sense of the unexpected, the contrast between what they already knew and what was expected in a new situation provides a way of framing the journey they made together. By using a series of contrasts an analysis of their experiences was made possible.

Four sets of overlapping worlds provide the vantage- points from which the experiences that constitute this study can be viewed. Three sets of worlds to describe the experiences of the participating teacher. These are, the world of the person who is good at science and the world of the person who is not, the world of the student teacher and the world of the novice teacher and the world of the elementary science classroom and the world of the elementary classroom during other subjects. The final set of overlapping worlds describes the researcher's development during this period. We have called it, the world of the specialist science teacher and the world of the generalist teacher. In each encounter with a contrasting world, it was necessary to find bridges or entryways (Roth et al.1993) to the new world in order that professional development could continue. Although these entryways were based in the original world or perspective we held, crossing them required reorganisation of ideas and attitudes so that successful transition to the new world could be made.

The non-science person and the world of science

Katie enjoyed science in the early years at school but began to have difficulties in Years 11 and 12. Gradually, she came to believe that her marks in science were not good enough and that she did not belong with the science students. Fearing failure, she put most of her effort into other subjects where she believed she could excel.

> I chose chemistry and maths 1 in my senior years, however they soon became my least favourite subjects. Success at high school was gauged by ones ability to obtain high achievements in maths 1, maths 2, physics, chemistry and biology. This was reflected by family, teachers and peers alike and as I was only an average maths and science student I felt I did not fit into the "Einstein" mould. I felt inferior as a result of not being able to achieve well at these subjects and this is the basis of my dislike in this field. I began to concentrate on theatre, music and economics, and science and maths took second placing. They began to be routine subjects which I felt I had an obligation to fulfil and as a result not much enjoyment came from them. As I look back now I realise I could have done well if I tried. However I was afraid of failing and disappointing those around me so I decided to stay away from these subjects and not run the risk of failing.
>
> (Katie, Journal, 9. 2 . 93)...

Katie seemed particularly prone to value "correct answers" and rote learning. For example, she was concerned that she could not remember much of her school chemistry and saw this as a result of her dislike of the subject.

> The lecture this week brought back memories of senior chemistry and many of the terms used were familiar. Even though the terms were friendly their definitions unfortunately were not. I am surprised at my lack of memory in this subject as during year eleven and twelve I could have recited the periodic table around exam time. It has only been two years since I left school and my memory is poor. Perhaps this has something to do with my dislike of these areas.
>
> (Katie, Journal 17 March 1993)

She worried about not being able to "copy down answers" during the showing of a filmstrip and was reluctant to interact with display materials in interactive work-stations while preservice teachers were studying light. In fact the one draw back to the work station approach, from Katie's perspective as a future teacher, was that children might touch the displays.

> The filmstrip was interesting however, it went too fast and I was unable to copy down the answers to the questions. I hope that more time is devoted to the topic, light, as I feel it has some tricky concepts to master. The stations around the lab. were a good idea as it allowed the class to comfortably and quickly see every display. This method would be useful in the school setting, however close supervision must be maintained as children tend to touch everything they see! A worksheet would have been useful for today's activity, just to give it a focus and to remember it by. Otherwise students tend to forget what they saw if they don't have a reminder.
>
> (Katie, Journal 31 March 1993)

Her tendency to see herself as outside a vast body of knowledge rather than as a generator of this knowledge is best illustrated by her inability to question the apparent results of an activities on electric circuits. When bulbs failed to light, she and her group did not check for faulty bulbs but assumed their ideas about current were incorrect.

> When our group predicted what we thought would happen when certain switches were closed, we found out we were wrong in some cases when we tested them out. This changed my views on electricity and caused confusion as I immediately thought I was wrong. I did not stop to think that perhaps the equipment was faulty.
>
> (Katie, Journal, 28. 4. 93)

Providing entry to the world of science

One of the most important aims of science education subjects at university was to assist preservice teachers to increase their confidence in their own knowledge of science and their ability to teach science at elementary level. In this way the subjects were designed to open the doors of the world of science students for the preservice teachers. Judith attempted while teaching to provide a learner-sensitive environment in which students were encouraged and supported rather than corrected or criticised. Co-operative learning was emphasised rather than competition and there had been a reduction in the amount of content so that new ides could be introduced gradually.

Although Katie had not been happy about her ability in science and believed it to be a reason for her rejection of the world of science, she drew on her science background at university. The co-operative learning suited her better than the competitive style of high school science, as did the university emphasis on hands-on experience rather

than lecturing. The change in learning environment seems to have assisted her to view her high school experience and her family's interest in science as entries into science rather than the closed doors they had previously been.

> Just having people, I suppose, the family, that knows a bit about it. Cause I'd often go home and ask them and then I'd go tell everyone in my group at university.... I suppose cause we had the books then at home too. Having extra books to look at was helpful. I didn't like science at high school. So I sort of was always worried about it at University, ... the group, having the four in the group that we did. Because everyone at one stage knew something that no-one else did so they'd often tell you and you'd think, oh, you remember that. So that was good. Doing, actually doing experiments. Not just hearing about it but doing it.
>
> (Katie, Interview, 1. 12. 94)

We were interested to find that Katie saw the relevance of providing access to the science world for her own pupils. When Katie taught a unit on chemical change to her field experience class she found that the children asked her what the name of the subject they were studying would be at high school. She took the opportunity to reassure them about their ability to do science.

> I brought along a grade nine science book because I had got some information out of that on chemical change. I said, " Everyone we were just doing a bit of grade nine work." And they went, "Oh, were we? Wow." And I said, " should be interested in science. Don't be frightened of it. ..."I was saying to them what should have been said to me, you know, don't be frightened of it."
>
> (Katie, Interview, 1. 12. 94)

Katie described elementary science as a beginning leading to what was to come in the future. The importance that she gave to this beginning explains to us her motivation for continuing to teach science during her first year of employment in spite of the evidence that other teachers did not. Katie acknowledged that elementary schools lacked the facilities for science teaching that were provided in the secondary setting. However, she stressed the importance of familiarity with science as a way of building confidence.

> I think we're trying to get them interested in it for high school. That's what I think anyway. Because um, when they go to high school, science is much more interesting - they've got the room, got all the stuff around you, and if you haven't been used to it, you might find it a little bit frightening or, I don't know what to do, I don't know how to do science, type of thing.
>
> (Katie, Interview, 18. 12. 95)

The world of the preservice teacher and the world of the inservice teacher

Katie found her transition from the world of the university-based preservice teacher to the world of the inservice teacher to be daunting. She had some difficulties with all aspects of school life and not just science teaching. She was faced with the reality of her own lack of experience with children and the fact that field placements had not taught her realistic ways to manage classrooms. She came to her first teaching position with expectations that her class would be on task and well behaved all the time. Her concern about being in control was a major difficulty.

> I think I was too, too concerned with being really quiet and being on task all the time every minute of the class time and not giving them a chance to have a break and talk and chat and then get back to it. I used to pull up everybody every second.
>
> (Katie ,Interview, 9. 8. 95)

Katie began to realise that some of the techniques she had used to manage her classes during field experience were not appropriate in her own class.

> But the pracs in a way were just satisfying the prac teacher type of thing and that's all. I mean there was some degree of everything else like controlling and interacting with the kids but for four weeks, you know, it wasn't really long enough to get anywhere but, it was very surface. Like we do surface things to get the kids on your side. Knowing in the long run that if I had a class of my own I could never do this, like give out the lollies or the tickets all the time to get them to listen but you're only there for four weeks so you do things that will last for four weeks. Its a lot longer than four weeks when you're really in a classroom.
>
> (Katie, Interview, 9. 8. 95)

The temptation to take shortcuts during her time as a preservice teacher had proved too great to resist. Thus field experience was not an adequate entryway to the world of the inservice teacher and Katie was left to find her own entry to effective teaching during her first year of employment.

Entryways to success as a classroom teacher

Becoming more relaxed about teaching and changing her views of success became entryways for Katie during 1995. She had found her novice status difficult and had used the metaphor of "doing time" when talking about gaining experience.

> Yeah, well I suppose like when you do this whole year next year again you've done that lesson and you remember from last year that you, you know, you've got to tell them that before you start. So things like that well I wish you had it now but you can't you know. . That's exactly what I want, experience without actually doing the time.
>
> (Katie, Interview 9 August 1995)

Katie's planning during field experience had been very detailed and time consuming and she became tired during the initial terms of 1995 trying to live up to her own expectations in this regard. To her surprise she coped better after a holiday during which she took time off rather than preparing for the coming term.

> I remember my first Easter holiday, I spent the whole week just doing work. And I came back in term two and I was really tired and really cranky. And um, and the next holidays, I didn't do anything and I came back more refreshed. And I sort of did it during the nights for the first week, you know. ...even the difference in the kids when they came back from holidays they were just better behaved you know than they had been you know I was coming to the end of the day and I didn't feel as tired as ragged as I had been they were just a lot easier than they had been.
>
> (Katie, Interview, 9. 8. 95)

Toward the end of 1995, Katie acknowledged that she was changing her view of what success as a teacher meant and learning to have realistic expectations of children.

> I suppose it was changing my view of being able to master things. You know I would just, took up, say, the piano. I'd just keep practising till I got it right. When I got the song right I was happy. And so I was thinking if I hadn't got this right, so I'm not doing, I'm just doing something wrong. What am I doing, you know. And then after six months you realise that you're not doing anything wrong, you're just thinking, you're putting too much, sort of, putting too much into it for a start. You know, you're expecting too much of the kids. That they be good all the time.
>
> (Katie, Interview, 9. 8. 95)

An important step toward effective teaching for Katie was learning to acknowledge the needs of the children in her class as well as her own needs. Her previous experience, exemplified by her description of learning the piano, had not required her to take others into account when striving for success.

The world of the science classroom and the world of other classes

Co-operative learning groups and hands-on activities during university based science classes had provided Katie with entry to the world of science while at university. She expected to be able to implement such lessons in elementary classrooms. However, field experience was something of a disappointment in this regard. Katie claimed that she seldom saw science taught by experienced teachers and sometimes did not complete the teaching of prepared science units. She had difficulties with management of science lessons. Supervising teachers did not seem able to support her in developing the skills necessary for using co-operative groups and hands-on activity. In fact, Katie found it difficult to become the science teacher she had hoped to be.

Managing group work was a challenge for Katie. On one occasion when she was teaching a Year three class about eggs, her groups were too large and she allowed children to work in places where she could not see them. The children misbehaved and the supervising teacher intervened by stopping group work and putting them into a large circle to watch teacher demonstrations. Katie was disappointed about the lack of real hands-on activity.

> In the conclusion I took the children outside and sat them in a circle... I discovered that a change of environment and a circular class group does work for control in the science lesson. This however contradicts an important objective of science in the elementary school, "hands-on". I found that as soon as the children were in their groups doing "hands-on"

investigating with the egg they were difficult to control and monitor. The noise was exceedingly high and the children were mucking around.

(Katie, Journal, 24. 4. 93)

While teaching a solubility unit during field experience at a boys' school in following year, Katie came to realise that group work was a novelty for this class. The boys loved science groups but misbehaviour was again common. The boys did not use the substances provided for investigating solubility correctly but had fun mixing everything together.

> It was very hard with all the boys. Every group had it all mixed by the end of the lesson. It was terrible. They had everything all in the one container, the oil and everything and all the different things like sugar and salt. They enjoyed it, they really loved the science. They said that it was great. And it worked because that class was just rows the whole time. They never went out of their rows.
>
> (Katie, Interview, 1. 12. 94)

Katie remained determined to teach science in her own classroom. However, effective entry to the world of the science classroom had been limited by the lack of real support for science teaching during field experience. Katie planned to teach science during her first week at school to get the children interested. She read the state science Sourcebooks during her summer holiday to find a unit she wanted to use. However, when she arrived at school for the "pupil free days" she found that a new science curriculum resource *Primary Investigations* was to be introduced. Although these materials were based on a co-operative learning model, initially, Katie felt unable to introduce group work. The first science lesson for Year six was called "liquid layers" and was designed to assist children and teachers to practice co-operative learning skills. The science content was interesting but of secondary importance to the skills. The experienced teachers were very worried about the way children would behave during the lesson and decided not to do it. Katie was influenced by the other teachers and used the teacher demonstration with pupil assistance method she had found successful during field experience. It seemed ironic to us that the lesson designed to allow emphasis of group skills was thought to be to demanding for children without these skills, and avoided or modified so as to make it ineffective. Thus all the classes proceeded to the next phase of the science unit without any practice at group work. Katie lamented the children's lack of co-operative learning skills but seemed to be encouraged by their enthusiasm for science.

> I just think it was particularly difficult to do something to do a unit like this like Primary Investigations with these type of kids you know in grade six, me there, first year, I just sort of felt that I couldn't do it all at once. I didn't know whether to choose or to concentrate on co-operative learning and really do that or just get the content across as quickly as possible and you know something like that. The teacher last year, until she retired end of last year,... was a very old lady. You could tell from day one they were just used to writing and sort of old fashioned type things not, when I wanted to do something different, they didn't know what was happening. Science was a bit different for them altogether, they did love it there wasn't one kid that didn't like science when we did it and I was the only one that shuddered when we did it. (Laughing)
>
> (Katie, Interview, 27. 6. 95)

The management of groups was not the only difficulty the novice science teacher faced during science lessons. Managing equipment was equally challenging. Katie found managing equipment particularly hard because so many of the *Primary Investigations* lessons involved manipulatives. When the class was making balloon powered cars she commented that, "some children were distracted with the materials. (I had rubber band flicking and paddle pop stick knives for days)''. We deduced that this was fairly typical behaviour encountered by teachers, when Katie told about the concern expressed by the experienced teachers during the inservice program when they found out what materials were needed for the introductory lesson "liquid layers."

> The other grade six teachers their mouths just about dropped open, "what!" they said "can you imagine coloured water, rubber bands, straws and water in the same room."
>
> (Katie, Interview, 27. 6. 95)

Katie avoided management problems by doing this lesson as a teacher demonstration. In future lessons she was aware that manipulatives could cause difficulty and tried to restrict their use. However, the lesson was often modified as a result and limited materials led to increased time when children were waiting with little to do. During Judith's first visit to Katie's classroom Katie was teaching an introductory lesson about energy during which the children made a cardboard toy that incorporated a rubber band which could be stretched and released making the toy, the "flic-flac",

jump. The children became noisy and argumentative, especially when they had to wait to use equipment or were watching demonstrations. Katie was concerned about allowing children to use scissors to punch holes in the cardboard but there was only one hole-puncher for the entire class. When Judith suggested that it might have been better to pre-punch the cardboard Katie said that she felt the children needed to be kept busy. However, she had restricted the number of "flic-flacs" made by each group to one, in order to reduce the amount of equipment in the room, thus defeating her aim of having all the children busy. Having only one "flic-flac" per group prevented children comparing toys within their own group in order to deduce which had the most energy and necessitated a whole class demonstration of the toys to make this comparison. Children became restless and management was a problem. Katie was torn between allowing the children to participate fully in hands-on activity and keeping materials at a level she felt she could manage.

Entryways to successful group work and effective management of equipment and manipulatives

Entryways into the science classroom were difficult when Katie was simultaneously trying to find entryways into the teaching profession generally. One of the most effective entryways to successful group work, seemed to be knowing individual children. Katie found that, as the term progressed knowledge of children assisted her to organise groups so that they were on task and also took friendships into account. At first she had selected groups that seemed to her to keep the most difficult children apart. One of the boys pointed out to her that girls always got to sit with their friends but that boys did not. From Katie's perspective this was because the girls did not allow their differences of opinion to disrupt the class as the boys did. In the next term Katie felt confident enough to change her approach.

> second term I changed my approach altogether. I started to put them with their buddies, not totally, with the group with two of their cronies, but with another one they do get along with really well and use it like that way. And it worked a bit better. But the biggest problem with Primary Investigations is the group co-operation.
>
> (Katie, Interview, 27. 6. 95)

Unfortunately, organising groups to ensure acceptable behaviour was easier than getting the group members to work well together during class. Conflicts when children felt that they had been excluded from an activity arose throughout the term.

Entryways to relative success in the second term of the year were provided by a unit on astronomy. Katie immediately saw the benefit of having, what she termed, "tamer" manipulatives in the room and using teacher demonstration rather than group investigation. She described these lessons as more like maths lessons. The children made individual planispheres out of paper and watched a video about planets.

> This unit looks like its going to be good, just about everyone likes Astronomy and there is not much group work!! (sigh). Most children were able to construct their star maps and every member of the class made one so there was no arguing or the like. I think Astronomy is every teacher's favourite topic in Science, it's definitely mine. There are few messy experiments and it's very fascinating studying the night sky. I suppose it is really "theory" science and there's not much opportunity for "hands-on".
>
> (Katie, Journal, Term 2, 95)

The *Primary Investigations* teacher guide proposed that groups of children model movements of the sun, earth and moon during eclipses. Katie modified this lesson and did a teacher demonstration with pupil assistance.

> It did suggest you have a balloon and use that as the earth and torch and tennis ball for the moon and the sun. I sort of felt it would be easier to get the information across if I did it myself and just got different kids up to do it, we did it a few times, we drew a picture on the board and what it looked and, I felt that was easier than explaining it in groups. For the time wise it was probably better but I know that it is not part of the whole Primary Investigations.
>
> (Katie, Interview, 27. 6. 95)

Because of her success with this unit and her understanding of the need to know individual children in order to manage her classroom effectively, Katie chose to do the astronomy unit first the following year, and reported that it had been a great success. She organised an astronomy evening for the Year 6 classes and invited a local astronomical society to assist her.

Katie did find other ways to manage science materials effectively. A successful lesson involving hands-on activity was one on electricity in which Judith supported Katie by providing equipment organised into kits. Katie allowed only half the class to do the activities at a time. Judith noticed that she was fairly relaxed about the children's exploratory behaviour on this occasion and allowed them to investigate the conductive properties of a range of things in the classroom as well as those provided in their equipment kits. The smaller number of children made less noise and fewer manipulatives were required to have the children fully involved in the activity. These factors, combined with Katie's changing view of appropriate behaviour for children, gave Judith the feeling that she was happy with the management of the lesson. Teaching the lesson twice was also an advantage. The first half of the class were reluctant to pause during their investigation and answer questions suggested in the lesson guide. Katie learned from her experience and had the satisfaction of a more smoothly flowing activity the second time by keeping all the questions until the end of the lesson. In this instance working with a smaller group of children and using equipment kits, provided an entryway to successful science teaching. We were surprised that Katie had not used these strategies more often as they seemed to us to be particularly appropriate for beginning teachers.

Katie seemed to hold strong beliefs about, and commitment to, investigative teaching strategies and attempted co-operative hands-on approaches during subsequent units in her science program. The strength of her beliefs, and the enthusiasm of the children during science lessons, were strong incentives to continue to look for entryways to the science classroom. However, Katie found that teaching science was not as enjoyable an experience as she had anticipated.

> I thought it'd be a lot different that's all. I thought it would be a bit, better than what it was. Easier than what it was. Having, um, all the kids really interested all the time, and just love science. They did like it but, and I really liked teaching them on prac, cause I think I was the only person that taught them science the whole year. But, it just wasn't like that all year round. And it could never be like that all year round cause pracs. are different. But I don't know, I just thought science would be happier for me, rather than sometimes thinking, oh well, science, you know, group work.
>
> (Katie, Interview, 18. 12. 95)

The world of the specialist teacher and the world of the generalist teacher

The contrasting of these two worlds brings a new dimension to this analysis. The teacher participant is, and will probably remain, a generalist teacher. We are science graduates who have taught as science specialists at secondary and tertiary level and are unlikely to become generalist teachers. However, we are also science educators of generalist teachers, hoping to find ways of improving our ability to facilitate their learning and teaching of science. In order to do this we can see a need to more fully understand the world of the generalist. Aspects of science teaching that we as specialists take for granted, such as dedicated space for science teaching, support with the provision and organisation of equipment, the relative importance of science in the curriculum and an adequate knowledge of science concepts, were we found, frequently absent from the world of the generalist teacher. It was easy to see the generalist world as defective in comparison with that of the specialist, rather than as a reality in which the generalist must operate. As with the other contrasting worlds discussed, we could see entryways the generalist participant used to provide access to the specialised area of science for her class. In contrast with the other paired worlds, some of the differences seemed to us, in this case, unbridgeable. We could imagine ideal entryways but they did not seem to be available in the generalist teacher's world.

Absence of space for science teaching

Our university classrooms are spacious and furniture is arranged so that students sit in groups. There is a wide area between the tables and special work-benches around edge of the room where there are power points, gas outlets and running water. In contrast, the elementary classroom where Katie taught was relatively cluttered with desks taking up much of the floor space. The floors were carpeted and desks and shelves were full of books and papers. Even the colourful displays of children's work limited space for groups. Thus space for children's activities was an important factor to be considered when arranging the furniture in the classroom. Judith noticed that Katie varied the groupings of desks throughout the year. Initially, Katie tried a desk arrangement consisting of clusters of six desks. This facilitated movement into science groups as each cluster contained two groups. It also left a relatively large floor space between groups of desks. The down side was that the six children in each cluster were very close together and able to chatter and to interfere with the work of others. Subsequently, the room was rearranged as rows of alternating double and single desks. Katie said this was because the larger groups were getting too noisy, but she regretted that most of the floor of the room was now taken up by desks. During a lesson

involving the use of pendulums, when this desk arrangement was in place, it was particularly difficult for children to find room to work where they could swing a pendulum without knocking that of another group. We began to understand that using "tame materials" such as planispheres, not only made children's behaviour easier to manage, but also suited the classrooms where children had to work in close proximity to one another.

One entryway to better teaching conditions that Katie tried toward the end of the year, was to split the class in two and have half the children at a time doing science. This was particularly effective in the electricity lesson already described. However, there were some problems with the arrangements. One half of the class had been sent to the library with a teacher aide, but found that the teacher librarian was absent. Students were not allowed in the library without a teacher. When Judith suggested allowing the other half of the class to remain in the classroom room or on the veranda outside and have a different activity, a process used in reading lessons, Katie was not confident that she could manage this.

> I think it'd be too difficult because um, like they want to come in, they want to have a look what they're doing. They just can't stand the fact that they're doing something else and people are doing science or something fun. They don't seem to realise that they're going to be doing it soon anyway. ...Its more trouble that its worth.
>
> (Katie ,Interview, 7. 11. 95)

Katie suggested an alternative way of providing space for the following year. Some new classrooms were to be built and she was hoping that at least one of the old classrooms might be put aside as a special science teaching area. We saw this as an excellent solution to the problem of space, a possible rather than an actual entryway that satisfied our specialist's sense of appropriate science practice.

Absence of support for obtaining and organising equipment

Another contrast between our science classes and those of generalist teachers is the help we have in collecting and managing manipulatives. When we plan science activities we leave a list of requested items with a laboratory technician whose role is to obtain, maintain and organise these items. He/she will also test activities to ensure that any adjustments needed are made before the students come to class. There was no such help at Katie's school. The school based system of management for science materials, a trolley of equipment for each school building, was in need of revision to suit the new curriculum. Katie had checked the trolley in her building but did not find any of the items she needed for her science lessons. As a result, she collected or purchased all the science materials she needed herself. At the end of her first year as a teacher, she told me about a staff meeting during which plans for managing equipment were discussed. The teachers at this stage had all been using *Primary Investigations* for a full year without an update of the school program for obtaining and managing equipment.

> Well the teacher who's the key teacher for science had a day off last term and she went around and organised the equipment. We were talking about it at a staff meeting and there's a bit of a debate about how we should organise it. There was one suggestion that we have a shed, like a science shed and just put everything in there and then the science teacher, the key teacher, would go and prepare everything for the classes and people were saying "that's too much work" for one person. Why don't we get it ourselves, and then she said, well, you know, teachers never put things back, or keep them in their room. The other suggestion was, something like a cupboard in each room. But then people were saying "but we have something similar to that, like science trolleys", its not for each year level, its just for each building, but some teachers said they had the science trolley in their room and some of the kids were just getting things out of it or people, other teachers were borrowing from it and weren't returning it. Just things like that. So they haven't sort of decided how they're going to organise the equipment.
>
> (Katie, Interview, 18. 12. 95)

The teachers seemed to find deciding on a system of management a difficult task. During an interview with Katie, Judith became aware that anticipated difficulty in obtaining equipment could be a reason for avoiding a topic. Judith had spent considerable time at university assisting the preservice teachers with concepts in electricity and wondered why Katie suggested skipping a lessons about electricity. Katie explained that she had been going to avoid this lesson because she thought that bulbs, cells and wire would be too difficult to obtain. When Judith provided kits, Katie willingly included the lesson and described it as her most successful science lesson that year. As with solutions to the problem of providing adequate space for science, we could see that, from our perspective, more adequate entryways to successful management of science materials needed to be found.

The status of science

Another contrast between the worlds of generalist and specialist teachers is the relative importance of science in the curriculum at elementary school in comparison with its importance at secondary school or university. At times when school life became particularly busy, science was omitted. After Katie's success with the electricity lesson, Judith left the equipment kits at school for the other year six teachers to use. Katie was enthusiastic about some of the extension activities in electricity and some printed materials were left with her. However, no one else made use of the kits and Katie did not do any extension work. She explained by saying that all the teachers were very busy at the end of the year and that she herself had not taught science again after November 7, even though there was still a month of school term left.

Participation in the study conferred on Katie the status of being an "expert" science teacher, and helped in building her confidence. She was very pleased at the way the school principal explained the study to a difficult Year six child before the first observation.

> I think, a lot of the kids really bloom in grade six in a way in they're just rebellious and really testing me to the limit especially this one boy he often says when he's having his tantrum, "you can't handle me, you don't know what to do, you know, things like that. You don't know what you are talking about", often, all the time, he told me that my planisphere was wrong, said "its wrong, its wrong", or "those constellations are wrong" and I found myself having to justify ... I showed the book I showed the page, I said that if you have a problem with this you take it up with Primary Investigations. You know I didn't draw it. …he found out that I was a first year out too. He said that I didn't know what I was talking about in that I don't know how to teach. Even my principal went and told him that I have a lecturer coming out from the University and to watch me in the class ... and she really built it up to this kid that she's not just a little first year or something ...I thanked (the principal) for doing that.
>
> Katie, Interview, 27. 6. 95)

We were aware when Katie was interviewed at the end of 1996 that something interesting had happened in terms of the prioritising of science. Katie had agreed to teach all the Year six science during 1996. This meant having three classes for science. We were initially concerned that this might restrict science teaching as the other teachers had been reluctant to teach science in 1995 and might want to limit the amount of science taught. However, science was actually protected by the more important subjects, mathematics and English, that the other teachers did on rotation while Katie taught science. This meant that on the whole Katie had science in each class every week. We were surprised at her comment that she spent more time preparing science and reading about the topics she taught in 1996. She claimed that it was worth doing this now that science was three hours of her teaching time each week. Increasing the relative importance of science for one teacher in a year level seemed to us to be one of the more appropriate entryways from the world of the generalist to the world of the specialist.

Science knowledge

As an observer in elementary science lessons Judith was most aware of her own feelings of unease when she thought she detected evidence of the possibility of limitations to children's learning that could arise from teachers' inexperience with science concepts. Because Judith believes that she does not to expect generalist teachers to have the same depth of knowledge as specialist teachers, she was surprised at her tendency to focus on what she perceived to be teachers' difficulties with science concepts. Katie had experience with science at high school and good access to resources at home. Judith did not detect many instances where she was uncomfortable with the way science concepts were developed in Katie's classes. Katie was aware that the children she taught would challenge her if they thought she was unsure of the content of any lesson. She was particularly concerned about her knowledge in the early stages of the year when her own feelings of newness and inexperience were overwhelming.

> If I don't know the content there's no way I will teach it I'll not get up in front of thirty kids and have them think that I don't know anything because they're already thinking that, that's what I think, I don't know whether they do think that. I felt they were all just, you know, they could see right through me like I was that stupid I didn't know anything.
>
> (Katie, Interview, 9. 8. 95)

On two occasions Katie took the opportunity of clarifying ideas with Judith before she discussed them with the children. Once she asked about the difference between energy change and energy transfer. The teachers' notes in *Primary Investigations* explained this well but Katie said she had found it "a lot to take in" and may not have related the general information about energy at the beginning of the unit to this specific lesson. On the other occasion she checked the direction of current flow in a series circuit. *Primary Investigations* used conventional

current flow rather than electron flow that Katie had used at school and university. At the end of the lesson on electricity, the Year six children began to test the conductivity of a range of items in the classroom. One boy was unable to get a current to pass through a small magnet. Other children began to speculate about why this should happen. A suggestion was made that the magnet pulled all the energy in and held it.

Katie	Hands up .....
Child	Could we try a magnet?
Child	It doesn't work.
Katie	A magnet?
Child	It doesn't work.
Katie	A magnet has a positive and a negative in itself.
Child	That's why it doesn't work.
Child	It still works.
Katie	Lets leave it till later Matthew. Its only a ..... experiment. Lets stick to what we're doing now. Katrina?

A further discussion of insulators followed but the child who was investigating magnets persisted.

Child	Can we try a magnet?
Katie	What do you want to try with it?
Child	.. doesn't work.
Child	Yeah because yours has got paper on it.
Child	We used a magnet.
Katie	Oh you did.
Child	Matt, why it doesn't work is because magnets .... because of the energy so its actually pulling in all the energy and not letting it out again. Like one ends pulling the energy,

(Observation 7 November 1995)

Judith was disappointed that Katie did not acknowledge this conversation nor suggest ways to check the theory. Katie spent more time reading around her science topics during 1996 when science became a more important part of her teaching role. She described how she often went to a library at the week-end to get extra resources and better information about topics.

We, as science educators, claim not to expect the content knowledge of the generalist teacher to be similar to that of a specialist yet we remain concerned about the generalist's knowledge base. The question becomes what level of knowledge is adequate for effective teaching? How close should the two worlds come and how should the entryway between them be built? The actual entryways provided by the teaching resources did not seem adequate. One other possibility was the increased importance of science, which, in Katie's case, made it worthwhile to spend more time in preparation for science teaching.

CONCLUSIONS

Unlike preservice elementary teachers described in the literature (Fensham, Navaratnam, Jones & West, 1991), Katie had studied science at school, however, some of her experiences were negative. She came to university with naïve realist views of science as a body of discovered knowledge separate from human beings (Abell & Smith, 1994; Gustafson & Rowell, 1995) and saw learning science as memorising facts. From our perspective as science educators, there is evidence that Katie began her first year of employment determined to teach science which

suggests that she had found entryways to the world of the science classroom. Her experiences at university and at school indicated that success as a science student and the confidence that results from this, were important entryways to the world of science. Judith attempted to assist preservice teachers to experience success at university, by providing a learning environment suited to their needs. Katie named the most helpful features of science education subjects as hands-on experiences and the co-operative nature of group work.

During her preservice field experience Katie, unlike the teachers described by researchers (Appleton, 1984; Henderson, 1992), did appear to become confident about science teaching. However, her supervising teachers seemed, like those described by Yates and Goodrum (1990), to teach little science and to avoid investigative strategies when they did. There is evidence in the comments Katie made that the children's enjoyment of her science lessons and the fact that these lessons were a novelty in her field experience schools were sources of encouragement for her to continue teaching science. However, once in the inservice school setting new barriers to the world of science were in place and new entryways needed to be found. Katie persisted with science teaching but without the enjoyment she had anticipated. Like teachers described in the literature (Goodrum, Cousins & Kinnear, 1992), she found management of children's behaviour and science manipulatives particularly difficult.

Katie's experiences led her to see that teaching children the skills of working in groups was a necessary entryway to successful science classes. On occasions, alternative entryways were provided by teacher demonstration, whole class discussion and pencil and paper manipulatives. These entryways gave Katie a respite during the astronomy unit. Experience in teaching was an obvious but effective entryways for Katie to an investigative hands-on science classroom. Experience brought realistic expectations of children's behaviour, knowledge of individual children and familiarity with the curriculum. Teaching experience also brought practice with science concepts not developed during university study. As a specialists, we were concerned with the need for continuing Katie's development of science knowledge. However, increasing the relative importance of science in the curriculum did encourage Katie to spend more time in preparing to teach science in 1996.

Katie has grown and changed during the course of the study. Just as she continued to look for ways to become a successful science teacher at elementary level, we too were looking for ways to improve our teaching, to grow and change. The study offered us insights into the worlds from which the generalist teachers came and the new worlds to which they needed to find entry. We have found that better understanding is an entryway from the perspective of the critical outsider to the perspective of the empathetic facilitator. An anthropological framework suggested by Aikenhead (1996) can be used to interpret the changes in perspective negotiated by Katie and by both authors as border crossings between sub-cultures. Katie needed to make crossings into the sub-cultures of the science student, the classroom teacher and the teacher of science during this study, while we, the authors, explored the border separating us as specialists from the world of the generalist teacher.

We have claimed to want to move from holding a deficiency model of teachers needs and existing knowledge to respecting their current knowledge in a constructivist way as a valid starting point. The term sub-culture, when applied to the existing knowledge and way of operating of others, brought with it, for us, a sense of moral obligation to value and to try to understand. It is always difficult to imagine operating outside one's own culture. When we first began to try to think of students who disliked science, generalist teachers and beginning teachers as members of a different sub-culture, whose current understandings should valued and were valid, we had great difficulty. We had assumed, as have many in dominant cultures, that the science sub-culture was somehow "the real" sub-culture and that others needed to belong to it. As a result of this study we began to interpret some of our experiences and Katie's .. as examples of cross-cultural learning (Aikenhead, 1996). Cross-cultural learning allows the person encountering a different culture to incorporate into their own culture aspects of the new culture that seemed useful or simply to borrow from the new culture what seems appropriate without changing their own culture. These were powerful images of learning that suited the context. Katie had avoided assimilation into the sub-culture of science in the past and thus would be more likely to adopt some scientific values and behaviours and not others during her two science subjects at university. As a beginning teacher she brought with her to her first jobs some valuable ideas and skills which she needed to retain, but also she benefited from adopting some practices that were more realistic and viable in a school setting. We concluded that generalist and specialist teachers have different roles and different values and skills, that there can be useful mutual borrowing and learning but that complete change is not possible and maybe even undesirable.

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